GOLDTHWAIT (J.E.)

Tendon Transplantation in the Treatment of Paralytic Deformities

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TENDON TRANSPLANTATION IN THE TREATMENT OF PARALYTIC DEFORMITIES.[1]

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THE purpose of this paper is to call attention to the possibility of furnishing better mechanical attachments for certain paralyzed or only partially paralyzed muscles, as a part of the treatment of paralytic deformities. The same principles are to be employed in the treatment of deformities of other character; but it is my desire to confine this paper wholly to the consideration of the method as it is of use in the deformities which have resulted from some form of paralysis.

When this work was commenced it was my belief that it was largely original, but upon a more careful perusal of the literature, recently made, I find that in 1881 Nicoladoni operated upon a patient and attached one of the posterior peroneal tendons to the tendo-Achillis. Since then one or two other cases have been operated upon abroad, and there have been a few cases in this country. The operation, however, as it has been done, has never received public recognition and but one work on orthopedic surgery, with which I am familiar, even mentions it. Hoffa, in the last edition of his book, mentions Nicoladoni's case almost without comment.

From the cases which have come under my observation, it seems to me that the operation deserves a much more prominent position than it has received, and that the method is capable of much broader use. The procedure cannot, of course, cure a paralytic foot, neither is it to be applied to all cases of paralysis in which there is deformity; but in a certain limited number of cases the benefit to be derived from furnishing better attachments for the muscles is most marked. In certain partial paralyses the power which remains in the

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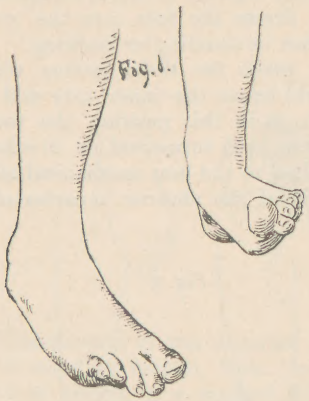
unaffected muscles is a disadvantage rather than a benefit, as these muscles, having nothing to antagonize them, by their contraction pull the foot, or the part, out of its normal relation with the other parts; and after these normal relations are lost the deformity increases more easily and more rapidly. If in these cases some operation can be performed which will keep the bones and joints in more nearly their normal relations, improvement results. A weak muscle cannot, of course, be made to do the work of a strong muscle, perfectly, but if this muscle, which has been working at a mechanical disadvantage and producing undesirable results, can be made to work in the right direction the patient is better off than formerly. The amount of improvement will depend upon the original condition, but all of the cases which have been operated upon have been improved. It has been possible to substitute simple forms of apparatus for complicated ones, and in one or two cases to dispense with it entirely. The patients also walk better, the limp being less marked.

Thus far the operations have been performed upon the feet, but there is no reason why the same principle should not be employed in other parts of the body. At the knee, undoubtedly, it could be employed to advantage in a certain limited number of cases, and very possibly at some of the other articulations, although the best results are to be looked for in those portions of the body where the tendons are well formed and lie superficially.

The cases to be selected for the operation are those in which one group of muscles has been destroyed, leaving the antagonizing or accessory muscles little if any impaired. This condition, if not treated, results in a definite deformity, simply from the muscular activity; and this becomes more marked as the age of the patient increases, partly because of the greater weight to be borne and partly because of the greater strength of the non-paralyzed muscles. In certain cases, as the deformity develops and increases, the mechanics of motion changes, so that the relation of the power to the fulcrum, and the fulcrum to the weight, or the portion moved, is entirely unlike the original condition. This is true in certain deformities at the knee, but is best demonstrated in the cases of infantile

paralysis, in which all of the posterior muscles of the calf are paralyzed with the exception of the two peroneals. The action of these muscles normally is to extend the foot at the ankle, and to abduct, or turn out, the front part of the foot, the fulcrum being the posterior edge of the outer malleolus. There being no



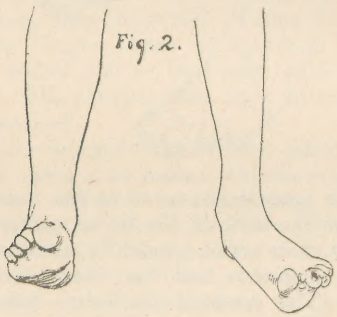
power in the gastrocnemius or in the muscles at the inner side of the back of the leg to control the peroneal muscles, their action gradually stretches the internal lateral ligaments and the whole foot is drawn outwards. The internal malleolus becomes more prominent while the outer malleolus is less so, owing to the turning out of the foot. Mechanically this places the outer malleolus, or the fulcrum over which the peroneal tendons act, distinctly inside the line of motion. As the result of this the tendons are gradually drawn outward until they slip over the posterior edge of the malleolus, and finally rest upon its outer surface, and in cases of long standing well toward the anterior edge. This position of the tendons is very well shown in Fig. 20, made from a photograph taken while the patient was attempting to extend the foot.

With the tendons in this position, the action of the muscles causes flexion and abduction, instead of extension and abduction of the foot as is normal. Fig. 1 is from a photograph taken with the patient attempting to extend the feet. The right foot, which is not

paralyzed, is extended normally, while the left is actually flexed as well as abducted. In this case all of the posterior muscles were paralyzed except the peroneus longus and brevis, and these tendons instead of being behind the malleolus were on the outer side near the anterior edge. It is evident that in such a condition the active muscles do harm rather than good, as their action draws the foot into the worst possible position for use in standing or walking.

The best place for these active muscles to be attached would be on the inner side and directly behind the foot, as in this position the foot can be extended and the arch supported, or, in other words, the power is applied to the best mechanical advantage.

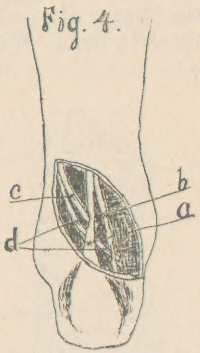
In paralysis of the anterior muscles of the leg, if



the paralysis is partial, those on the inner side are much more often affected, so that dorsal flexion of the foot is performed by the outer muscles, the extensor communis digitorum and the peroneus tertius. The result of this is that the foot is not simply flexed, but is flexed and abducted. This is shown in Fig. 2 and also in Fig. 19, in both of which the attempt at flexion was being made. In Fig. 2 the right foot is simply flexed while the left foot, the one that is paralyzed, is drawn up and out.

The absence of the anterior tibial, or the muscular power which is normally applied to the inner side of the foot in front, is noticed also in the action of the posterior muscles, and instead of simple extension at the ankle, extension and abduction also is the result, there being nothing in front on the inner side to steady

or control the muscles behind. Fig. 3 was taken with the patient extending the feet as much as possible. The right foot is extended, and if anything, is turned in slightly, while the left foot is turned out as well as



extended. This absence of the anterior tibial muscle in walking or standing results, from the position in which the foot is placed, in a gradual giving way of the arch, and a flat-foot of a greater or less degree.

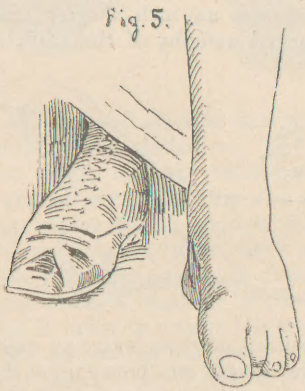


Fig. 15 illustrates an extreme type of this condition. It is obvious that, in such a case, if the active muscles could be attached to the inner side of the foot the usefulness would be greatly increased.

The following cases are reported with considerable

detail, as illustrative of the principles which have been expressed. Only those cases are reported which were operated upon at least three months ago, as the immediate results are of less value.

Case I. A young woman, nineteen years old, came to the Carney Hospital in October, 1894, for treatment of the left foot. When nine months old she had an

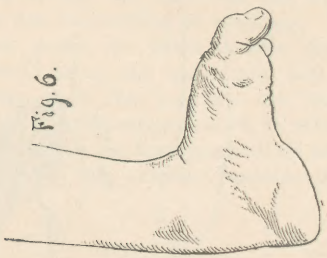


Fig. 6.

attack of infantile paralysis which involved the left foot. Walking has always been difficult, but of late, owing apparently to her increased weight, there has been considerable pain referred to the inner side of the foot, under the inner malleolus. It was because of this pain that she sought treatment.

The left leg was an inch shorter than the right; there was marked atrophy of the calf; and the foot

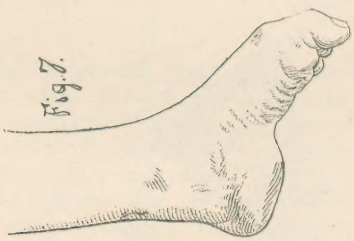


Fig. 7.

was in the position of most extreme calcaneo-valgus. In walking, the weight was borne upon the inner edge of the heel, the anterior portion of the foot being turned outwards fully forty degrees with the normal axis of the ankle-joint. The posterior muscles were all paralyzed, with the exception of the peroneus longus and brevis, and the tendons of these muscles were on the outer surface of the malleolus. The anterior

muscles were practically normal, and having no posterior muscles to antagonize them, their contraction caused such extreme flexion that the dorsum of the foot rested against the anterior surface of the leg.

The patient was admitted to the hospital and the following operation performed (Fig. 4). An oblique incision, four inches long, was made so that it crossed the tendo-Achillis about one inch above its insertion into the os calcis. Through this wound the peroneal

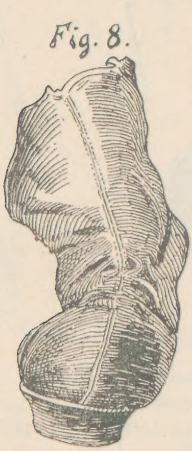


Fig. 8.

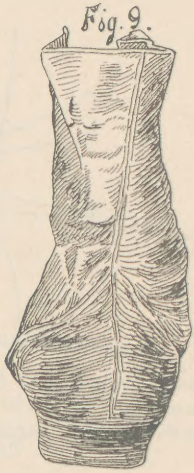


Fig. 9.

tendons *c* and *d*, were exposed and divided at about the lower edge of the malleolus. The tendo-Achillis (*a*) was then freed, and the tendon of the peroneus brevis (*d*) was passed under this and attached to the tendon of the flexer longus pollicis (*b*). The tendon of the peroneus longus (*c*) was then attached to the tendo-Achillis (*a*), after which the wound was closed and a plaster-of-Paris bandage applied, holding the foot extended in order to relieve the strain, as much as possible, from the sutured tendons.

The wound suppurated, so that fully six weeks were required for the healing, after which the patient was allowed to walk about without apparatus. One month later, because of the tendency to pronation, a valgus plate was applied, and this has been worn since.

The result in this case is best shown by the illustra-

tions. Fig. 5 shows the position as the weight is borne, the turning out of the foot being entirely corrected. The extreme flexion has been controlled, only that which is shown in Fig. 6 being possible. Extension is possible, as is shown in Fig. 7, contrasted with absolutely no power of extension before the operation. The improvement in the tread of the foot is strikingly shown by the boots worn before and since the operation. Fig. 8 is from a photograph of a boot which was

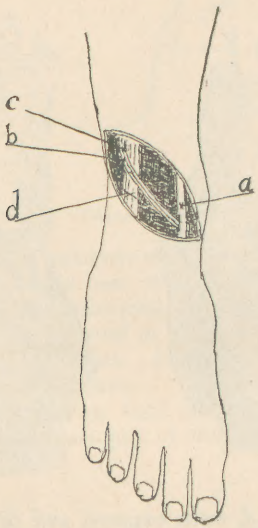


Fig- 10.

worn by the patient previous to the operation. Fig. 9 is from the boot which was worn for several months after the operation. The difference in the line of the heel is very striking. Without the operation it would have been necessary for the patient to wear an expensive apparatus probably for the rest of her life. As the result of the operation she is able to get along with a simple valgus plate, and with this she has been doing general housework for the past eight months, entirely free from pain or other symptoms.

Case II. A boy about thirteen years of age. When two years old he was paralyzed, the right lower leg and

foot being the parts affected. All of the posterior muscles were destroyed, with the exception of the two peronei, and all of the anterior muscles except the peroneus tertius and the extensor communis digitorum. As the result of this, all the power being applied at

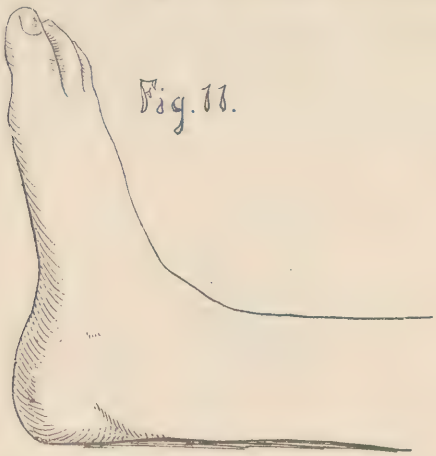


Fig. 11.

the outer side of the foot, and the posterior tendons being out of place, as described in the previous case, the foot was in the position of calcaneo valgus. Walking

Fig. 12.

without a crutch or an apparatus extending to the knee was practically impossible.

The patient was admitted to the Children's Hospital, and through the kindness of Dr. Burrell I was permitted to operate upon him. The first operation, which was performed about three and one-half months ago, was practically the same as that described in Case I.

Two weeks after this a second operation (Fig. 10) was performed, this time upon the anterior tendons, in the endeavor to furnish some muscular attachment at the inner side of the foot. An oblique incision was made across the front of the leg just above the ankle-joint, and the tendons carefully separated. The tendon of the peroneus tertius (*b*) and the outer segment (*c*) of the tendon of the common extensor (*d*) were then divided as low down as possible and attached to the tendon of the anterior tibial (*a*) muscle. The wound was then treated as in the other cases, sutured without drain-

age, and the foot done up in plaster-of-Paris for two weeks' time, after which moderate motion was allowed, the patient being permitted to walk at the end of the third week.

The result in this case is very good, the extreme valgus has been corrected, and a simple valgus plate gives all the support that is needed. The amount of voluntary flexion and extension is shown in Figs. 11 and 12. Before the operation there was no power of extension. It is also to be noticed that the motions are pure flexion and extension, the valgus being entirely corrected. Fig. 13 shows the foot with the weight borne before the operation.

Case III. A boy, twelve years of age, entered the Children's Hospital in August last, in Dr. Cushing's

service, and it was through his kindness that I was permitted to take charge of the case.

There was a marked valgus of the left foot resulting from an attack of infantile paralysis when two years of age. There was no contraction of the anterior tibial muscle and but slight response with the extensor longus pollicis. The other anterior muscles were normal, and the posterior muscles were normal except

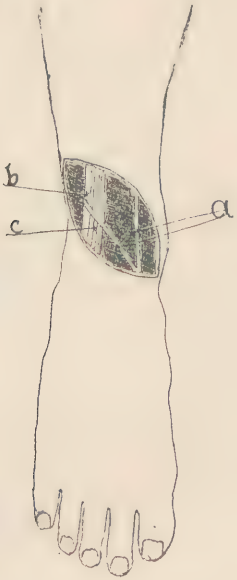


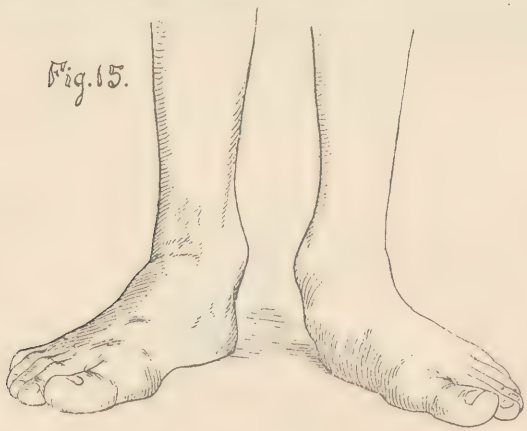
Fig. 14.

that there was a moderate amount of contraction of the tendo-Achilles, evidently due to the weakness of the anterior antagonizing muscles. On any attempt at flexion, the foot was drawn up and out, due to the point of attachment of the active muscles, at the outer portion of the foot.

The operation (Fig. 14), which was performed over three months ago, consisted in exposing the anterior tendons as was done in Case II, and then instead of attaching the peroneus tertius (*b*) to the anterior tibial

(*a*), the anterior tibial (*a*) tendon was split and attached to the peroneus tertius (*b*). This seems to me to be a better operation, as none of the attachments of the active muscles are sacrificed, but instead another attachment for these muscles is made.

Fig. 15.



The result in this case is most satisfactory; the valgus and abduction of the foot, which was so marked

Fig. 16.

Fig. 17.

before the operation (Fig. 15), has been entirely corrected, and even when all the weight is borne upon the foot, the arch is high and there is no tendency to the old flat-foot. Figs. 16 and 17 were both taken

with the right foot raised so that all of the weight was supported. The contrast between this and the condition before the operation (Fig. 15), in which only half the weight was supported, is very striking.

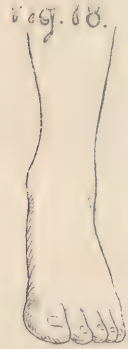


Fig. 18.

Fig. 19.

No apparatus whatever has been worn since the operation, and the child walks with the foot straight forward. On voluntary flexion the foot is drawn up per-

Fig. 20.

fectly straight (Fig. 18), in contrast to the flexion and abduction which was present before the operation (Fig. 19).

Case IV. A girl, ten years of age, whom I saw at the Children's Hospital, and later operated upon, through the kindness of Dr. Bradford. Both legs were paralyzed, the right completely, and the left par-

tially. In the left leg all of the posterior muscles were destroyed with the exception of the peroneals, and the

Fig. 21.

position of these tendons was on the outer side of the malleolus, as has been described and as is shown in Fig. 20. The anterior muscles were weak, but all

Fig. 22.

showed some contraction. From the position of the peroneal tendons, however, simple flexion of the foot was impossible, it being drawn up and out as is shown in Fig. 21.

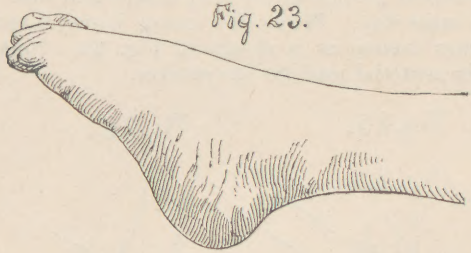
The operation, which was performed about three months ago, was the same as in the first case (Fig. 4).

The result in this case is best shown by the photo-

graphs. Fig. 22 shows the position of the foot with the weight borne, Fig. 23 shows the voluntary extension, to be contrasted with the condition before the operation, Fig. 20, and Fig. 24 shows the amount of voluntary flexion to be contrasted with Fig. 21.

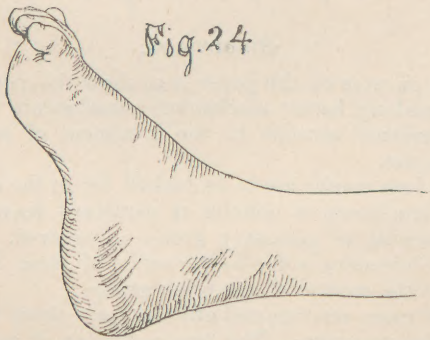
A valgus plate is all that is necessary to keep the foot in the proper position.

Fig. 23.



The method of attaching the tendons is of great importance, and unless they are firmly joined the benefit of the operation is lost. Tendons do not unite as readily as other tissues, so that it is desirable to offer as large a surface for adhesion as is possible. The fol-

Fig. 24



lowing method has proved very satisfactory, a method, which, I think, has not been used before. The tendon to which the attachment is to be made is split, and the end of the severed tendon, after it has been scored across to make the surface rough, is drawn through this slit and held by two quilted sutures. In this way both sides of the severed tendon become attached; and, to offer a still greater area for adhesion, the sutures are

so placed that when tightened the outer tendon is spread out. The arrangement of the sutures is shown in Fig. 25. The outermost suture is passed through both tendons and tied. The other is passed through the outer portion of the split tendon, then through the free tendon, from an eighth to a quarter of an inch away from the edge of the first tendon, then through the posterior portion of the split tendon and then back in the same way. When this suture is tied it spreads the outer tendon as is shown in Fig. 26. Fine silk was the material used for the sutures.

Fig. 25.

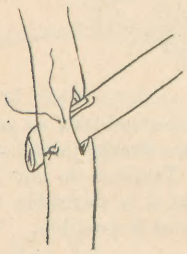
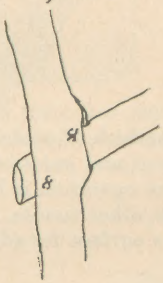


Fig. 26.



CONCLUSION.

The purpose of the paper is to show the possibility of furnishing better mechanical attachments for the non-paralyzed muscles in the treatment of paralytic deformities.

The best results are to be looked for in the cases in which one group of muscles is paralyzed, leaving the antagonizing or accessory group unimpaired. Much of the deformity is due to the action of these muscles without the control of the other group.

Four cases are reported after at least three months since the operation. The first case, that of an adult, was operated upon over a year ago. In all there has been a marked improvement. In three cases the peroneus longus was attached to the tendo-Achillis and the peroneus brevis to the flexor longus pollicis. In two cases the anterior tibial tendon was attached to the peroneus tertius.

The tendons were attached by splitting one and drawing the other through this and suturing them with quilted sutures.

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